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REISSUE PATENT APPLICATION TRANSMITTAL

Address to:	
Address to: **Assistant Commissioner for Patents** **Box Patent Application** **Washington, DC 20231**	*Attorney Docket No.* 2000-0722 *First Named Inventor* Masamichi NAKAHIBA et al. *Original Patent Number* 5,762,539 *Original Patent Issue Date (Month/Day/Year)* June 9, 1998 *Express Mail Label No.* *Total Pages*

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APPLICATION FOR REISSUE OF:
(check applicable box) [X] *Utility Patent* [] *Design Patent* [] *Plant Patent*

APPLICATION ELEMENTS

1. [X] Fee Transmittal Form *(PTO/SB/56)*
(Submit an original, and a cuplicate for fee processing)

2. [X] Specification and Claims
(amended, if appropriate)

3. [X] Drawing(s)
(proposed amendments, if appropriate)

4. [X] [UNEXECUTED] Reissue Oath / Declaration
(original or copy)
(37 CFR 1.175)(PTO/SB/51 or 52)

5. Original U.S. Patent
[X] Offer to Surrender Original Patent *(37 CFR 1.178)*
(PTO/SB/53 or PTO/SB/54)
or
[] Ribboned Original Patent Grant
[] Affidavit/Declaration of Loss *(PTO/SB/55)*

6. Original U.S. Patent currently assigned?
[X] Yes [] No
(If Yes, check applicable box(es)
[X] Written Consent of all Assignees
(PTO/SB/53 or 54)
[X] 37 CFR 3.73(b) Statement
[X] Power of Attorney

ACCOMPANYING APPLICATION PARTS

7. [X] Foreign Priority Claim *(35 USC 119)*
(if applicable)

8. [X] Information Disclosure Statement (IDS)/PTO-1449
[] Copies of IDS Citations

9. English Translation of Reissue Oath/Declaration *(if applicable)*

10. [] Small Entity Statement
[] Statement filed in prior application Status Still proper and desired

11. [] Preliminary Amendment

12. [X] Return Receipt Postcard *(MPEP 503)*
(Should be specifically itemized)

13. [X] Other
1. **Cover Letter for Application Filed Without Executed Declaration**
2. **Request to Transfer Formal Drawings from Patent File**
3. **Soft copy of USP 5,762,539**

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REISSUE APPLICATION FEE TRANSMITTAL FORM

Docket Number (Optional) 2000-0722

Claims as Filed - Part 1

Claims in Patent	For	Number Filed in Reissue Application	(3) Number Extra	Small Entity Rate	Small Entity Fee		Other than a Small Entity Rate	Other than a Small Entity Fee
(A) 11	Total Claims (37 CFR 1.16(j))	(B) 37	**** 17 =	x $____ =		or	18 x $____ =	$306.00
(C) 3	Independent Claims (37 CFR 1.16(i))	(D) 12	* 9 =	x $____ =			72 x $____ =	$702.00
			Basic Fee (37 CFR 1.16(h))		$___			$690.00
			Total Filing Fee		$		OR	$1,698.00

Claims as Amended - Part 2

	(1) Claims Remaining After Amendment		(2) Highest Number Previously Paid For	(3) Extra Claims Present	Small Entity Rate	Small Entity Fee		Other than a Small Entity Rate	Other than a Small Entity Fee
Total Claims (37 CFR 1.16(j))	***	MINUS	**	* =	x $____ =		or	x $____ =	
Independent Claims (37 CFR 1.16(i))	***	MINUS	*****	=	x $____ =			x $____ =	
				Total Additional Fee		$		OR	$

* If the entry in (D) is less than the entry in (C), Write "0" in column 3.
** If the "Highest Number of Total Claims Previously Paid For" is less than 20, Write "20" in this space.
*** After any cancelation of claims
**** If "A" is greater than 20, use (B -A); if "A" is 20 or less, use (B - 20).
***** "Highest Number of Independent Claims Previously Paid For" or Number of Independent Claims in Patent (C).

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June 8, 2000
Date

Michael Huppert
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APPARATUS FOR AND METHOD FOR POLISHING WORKPIECE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus for and a method of polishing a workpiece such as a semiconductor wafer to a flat mirror finish, and more particularly to an apparatus for and a method of polishing a workpiece such as a semiconductor wafer which can control the amount of a material removed from a desired area of the workpiece by a polishing action.

2. Description of the Related Art

Recent rapid progress in semiconductor device integration demands smaller and smaller wiring patterns or interconnections and also narrower spaces between interconnections which connect active areas. One of the processes available for forming such interconnection is photolithography. Though the photolithographic process can form interconnections that are at most 0.5 μm wide, it requires that surfaces on which pattern images are to be focused by a stepper be as flat as possible because the depth of focus of the optical system is relatively small.

It is therefore necessary to make the surfaces of semiconductor wafers flat for photolithography. One customary way of flattening the surfaces of semiconductor wafers is to polish them with a polishing apparatus.

Conventionally, a polishing apparatus has a turntable and a top ring which rotate at respective individual speeds. A polishing cloth is attached to the upper surface of the turntable. A semiconductor wafer to be polished is placed on the polishing cloth and clamped between the top ring and the turntable. An abrasive liquid containing abrasive grains is supplied onto the polishing cloth and retained on the polishing cloth. During operation, the top ring exerts a certain pressure on the turntable, and the surface of the semiconductor wafer held against the polishing cloth is therefore polished to a flat mirror finish while the top ring and the turntable are rotating.

The polishing apparatus is required to have such performance that the surfaces of semiconductor wafers have a highly accurate flatness. Therefore, it is preferable that the lower end surface (the holding surface) of the top ring which holds a semiconductor wafer and the contact surface of the polishing cloth which is held in contact with the semiconductor wafer, and hence the surface of the turntable to which the polishing cloth is attached, have a highly accurate flatness, and those surfaces which are highly accurately flat have been used in the art. The lower surface of the top ring and the upper surface of the polishing cloth are parallel to each other as in the ordinal cases.

It is known that the polishing action of the polishing apparatus is affected not only by the configurations of the holding surface of the top ring and the contract surface of the polishing cloth, but also by the relative speed between the polishing cloth and the semiconductor wafer, the distribution of pressure applied to the surface of the semiconductor wafer which is being polished, the amount of the abrasive liquid on the polishing cloth, and the period of time when the polishing cloth has been used. It is considered that the surface of the semiconductor wafer can be highly accurately flat if the above factors which affect the polishing action of the polishing apparatus are equalized over the entire surface of the semiconductor wafer to be polished. The larger the size of the semiconductor wafer is, the more difficult the above factors are equalized.

However, some of the above factors can easily be equalized over the entire surface of the semiconductor wafer, but the other factors cannot be equalized. For example, the relative speed between the polishing cloth and the semiconductor wafer can easily be equalized by rotating the turntable and the top ring at the same rotational speed and in the same direction. However, it is difficult to equalize the amount of the abrasive liquid on the polishing cloth because of a centrifugal forces imposed on the abrasive liquid.

The above approach which tries to equalize all the factors affecting the polishing action, including the flatnesses of the lower end surface of the top ring and the upper surface of the polishing cloth on the turntable, over the entire surface of the semiconductor wafer to be polished poses limitations on efforts to make the polished surface of the semiconductor wafer flat, often resulting in a failure to accomplish a desired degree of flatness of the polished surface.

It has been customary to achieve a more accurate flatness by making the holding surface of the top ring concave or convex to develop a certain distribution of pressure on the surface of the semiconductor wafer for thereby correcting irregularities of the polishing action which are caused by an irregular entry of the abrasive liquid and variations in the period of time when the polishing cloth has been used.

However, various problems have arisen in the case where a specific configuration is applied to the holding surface of the top ring. Specifically, since the holding surface of the top ring is held in contact with the semiconductor wafer at all times, the holding surface of the top ring affects the polishing action continuously all the time while the semiconductor wafer is being polished. Because the configuration of the holding surface of the top ring has direct effect on the polishing action, it is highly complex to correct irregularities of the polishing action by intentionally making the holding surface of the top ring concave or convex, i.e., non-flat. If the holding surface of the top ring which has been made intentionally concave or convex is inadequate, the polished surface of the semiconductor wafer may not be made as flat as desired, or irregularities of the polishing action may not be sufficiently corrected, so that the polished surface of the semiconductor wafer may not be sufficiently flat.

In addition, inasmuch as the holding surface of the top ring is of substantially the same size as the surface of the semiconductor wafer to be polished, the holding surface of the top ring is required to be made irregular in a very small area. Because such surface processing is highly complex, it is not easy to correct irregularities of the polishing action by means of the configuration of the holding surface of the top ring.

The conventional polishing apparatuses, particularly those for polishing semiconductor wafers, are required to polish workpiece surfaces to higher flatness. There have not been available suitable means and apparatus for polishing workpieces to shapes which are intentionally not flat or for polishing workpieces such that desired localized areas of workpiece surfaces are polished to different degrees.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a polishing apparatus which can easily correct irregularities of a polishing action on a workpieces such as a semiconductor wafer, and polish a workpiece with an intensive polishing action on a desired localized area thereof.

According to an aspect of the present invention, there is provided a polishing apparatus for polishing a surface of a workpiece comprising: a turntable having a polishing sur-

face thereon; a top ring for supporting the workpiece to be polished and pressing the workpiece against the polishing surface under a first pressing force, the top ring having a holding surface for holding the workpiece; a pressurized fluid source for supplying pressurized fluid; a plurality of openings provided in the holding surface of the top ring for ejecting the pressurized fluid supplied from the pressurized fluid source, a plurality of areas each having the openings being defined in the holding surface so that the pressurized fluid is selectively ejectable from the openings in the respective areas.

According to another aspect of the present invention, there is provided a method of polishing a workpiece, comprising the steps of: holding a workpiece between a polishing surface of a turntable and a holding surface of a top ring disposed above the turntable; pressing the workpiece by the top ring against the polishing surface under a first pressing force; and ejecting pressurized fluid from openings in a plurality of areas in the holding surface of the top ring toward the workpiece held by the top ring, the pressurized fluid being selectively ejectable from the openings in the respective areas; and polishing the workpiece in such a state that a pressing force applied to the workpiece by the pressurized fluid is variable in a central portion and an outer circumferential portion of the workpiece, respectively.

The above and other objects, features, and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings which illustrate preferred embodiments of the present invention by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary vertical cross-sectional view showing the basic principles of the present invention;

FIGS. 2A, 2B, and 2C are enlarged fragmentary vertical cross-sectional views showing the behavior of an polishing cloth when the relationship between a pressing force applied by a top ring and a pressing force applied by a presser ring is varied;

FIGS. 3A through 3C are graphs showing the results of an experiment in which a semiconductor wafer was polished based on the basic principles of the present invention;

FIGS. 4A through 4E are graphs showing the results of an experiment in which a semiconductor wafer was polished based on the basic principles of the present invention;

FIG. 5 is a vertical cross-sectional view of a polishing apparatus according to a first embodiment of the present invention;

FIG. 6 is an enlarged vertical cross-sectional view showing details of a top ring and a presser ring of the polishing apparatus according to the first embodiment;

FIG. 7 is a cross-sectional view taken along line VII—VII of FIG. 6; and

FIG. 8 is an enlarged vertical cross-sectional view of a polishing apparatus according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Like or corresponding parts are denoted by like or corresponding reference numerals throughout views.

FIG. 1 shows the basic principles of the present invention. As shown in FIG. 1, a top ring 1 has therein a circular first chamber C_1 at a central position thereof, an annular second

chamber C_2 disposed at a radially outer side of the first chamber C_1, and an annular third chamber C_3 disposed at a radially outer side of the second chamber C_2. The first chamber C_1 is connected to a pressurized fluid source through a valve V_1, the second chamber C_2 is connected to a pressurized fluid source through a valve V_2, and the third chamber C_3 is connected to a pressurized fluid source through a valve V_3. The top ring 1 has a recess la defined in a lower surface thereof for accommodating therein a semiconductor wafer 4 which is a workpiece to be polished. An elastic pad 2 of polyurethane or the like is attached to the lower surface of the top ring 1.

The top ring 1 and the elastic pad 2 have a plurality of openings 1*o* and 2*o*, respectively, which are in registry with each other. Each of the openings 1*o* and 2*o* is communicated with any one of the first chamber C_1, the second chamber C_2, and the third chamber C_3. That is, a plurality of openings each comprising the openings 1*o* and 2*o* for ejecting pressurized fluid are provided in a holding surface of the top ring 1 for holding the semiconductor wafer 4 to be polished. Thus, three concentric annular areas are defined on the holding surface of the top ring 1 by allowing the openings 1*o* and 2*o* to be communicated with any one of the first, second and third chambers C_1, C_2 and C_3. The pressurized fluid is ejectable from the openings in the respective annular areas, separately.

A presser ring 3 is disposed around the top ring 1 and is vertically movable with respect to the top ring 1. A turntable 5 having an upper surface to which a polishing cloth 6 is attached is provided below the top ring 1. The top ring 1 applies a pressing force F_1 (pressure per unit area, gf/cm^2) to press the semiconductor wafer 4 against the polishing cloth 6 on the turntable 5, and the presser ring 3 applies a pressing force F_2 (pressure per unit area, gf/cm^2) to press the polishing cloth 6. These pressing forces F_1, F_2 are variable independently of each other.

During polishing, pressurized fluid such as compressed air is supplied to the first, second and third chambers C_1, C_2 and C_3, selectively, and the supplied pressurized fluid is ejected from the lower surface of the elastic pad 2 through the openings 1*o* and 2*o* and is supplied between the holding surface of the top ring 1 and the upper surface of the semiconductor wafer 4. At this time, at least one of the first, second and third chambers C_1, C_2 and C_3 to which pressurized fluid is supplied is selected, and hence at least one of the annular areas, from which pressurized fluid is ejected, in the holding surface of the top ring 1 is selected. For example, pressurized fluid is supplied only to the first chamber C_1, and is not supplied to the second and third chambers C_2 and C_3, and thus the pressurized fluid is ejected only from the central area of the holding surface of the top ring 1. As a result, the semiconductor wafer 4 is pressed against the polishing cloth 6 by the pressurized fluid in such a state that the polishing pressure applied to the central portion of the semiconductor wafer 4 is larger than the polishing pressure applied to outer circumferential portion of the semiconductor wafer 4. Thus, if the amount of a material removed from the outer circumferential portion of the semiconductor wafer 4 is larger than the amount of a material removed from the central portion of the semiconductor wafer 4, insufficient polishing action at the central portion of the semiconductor wafer can be corrected by utilizing the pressing action of the pressurized fluid.

On the other hand, if the amount of a material removed from the central portion of the semiconductor wafer 4 is larger than the amount of a material removed from the outer circumferential portion of the semiconductor waiter 4, the

pressurized fluid is supplied only to the third chamber C_3, and is not supplied to the first and second chambers C_1 and C_2, and thus the pressurized fluid is ejected only from the outer circumferential area of the holding surface of the top ring **1**.

As a result, the polishing pressure applied to the outer circumferential portion of the semiconductor wafer **4** is made larger than the central portion of the semiconductor wafer **4**. Thus, insufficient polishing action at the outer circumferential portion of the semiconductor wafer can be collected, and the entire surface of the semiconductor wafer **4** can be uniformly polished.

The pressures of pressurized fluid supplied to the first chamber C_1, the second chamber C_2 and the third chamber C_3 are changed, respectively. That is, pressurized fluid having a pressure of p_1 gf/cm^2 is supplied to the first chamber C_1, pressurized fluid having a pressure of P_2 gf/cm^2 is supplied to the second chamber C_2, and pressurized fluid having a pressure of p_3 gf/cm^2 is supplied to the third chamber C_3, respectively. In this manner, the pressures of pressurized fluid ejected from the respective annular areas of the holding surface of the top ring **1** are varied, and the fluid which is supplied between the holding surface of the top ring **1** and the upper surface of the semiconductor wafer **4** has pressure gradient so as to be higher or lower progressively from the central area to the outer circumferential area of the semiconductor wafer **4**, and hence the pressing force for pressing the semiconductor wafer **4** against the polishing cloth **6** has gradient so as to be higher or lower progressively from the central area to the outer circumferential area of the semiconductor wafer **4**. Thus, irregularities of the polishing action can be sufficiently corrected, and the localized area of the semiconductor wafer **4** is prevented from being polished excessively or insufficiently.

In the present invention, the pressing force F_1 (pressure per unit area, gf/cm^2) for pressing the semiconductor wafer **4** against the polishing cloth **6**, and the pressing force F_2 (pressure per unit area, gf/cm^2) for pressing the polishing cloth **6** are variable independently of each other. Therefore, the pressing force F_2 which is applied to the polishing cloth **6** by the presser ring **3** can be changed depending on the pressing force F_1 which is applied by the top ring **1** to press the semiconductor wafer **4** against the polishing cloth **6**.

Theoretically, if the pressing force F_1 which is applied by the top ring **1** to press the semiconductor wafer **4** against the polishing cloth **6** is equal to the pressing force F_2 which is applied to the polishing cloth **6** by the presser ring **3**, then the distribution of applied polishing pressures, which result from a combination of the pressing forces F_1, F_2, is continuous and uniform from the center of the semiconductor wafer **4** to its peripheral edge and further to an outer circumferential edge of the presser ring **3** disposed around the semiconductor wafer **4**. Accordingly, the peripheral portion of the semiconductor wafer **4** is prevented from being polished excessively or insufficiently.

FIGS. **2A** through **2C** schematically show how the polishing cloth **6** behaves when the relationship between the pressing force F_1 and the pressing force F_2 is varied. In FIG. **2A**, the pressing force F_1 is larger than the pressing force F_2 ($F_1>F_2$). In FIG. **2B**, the pressing force F_1 is nearly equal to the pressing force F_2 ($F_1 \approx F_2$). In FIG. **2C**, the pressing force F_1 is smaller than the pressing force F_2 ($F_1<F_2$).

As shown in FIGS. **2A** through **2C**, when the pressing force F_2 applied to the polishing cloth **6** by the presser ring **3** is progressively increased, the polishing cloth **6** pressed by the presser ring **3** is progressively compressed, thus pro-

gressively changing its state of contact with the peripheral portion of the semiconductor wafer 4, i.e., progressively reducing its area of contact with the peripheral portion of the semiconductor wafer 4. Therefore, when the relationship between the pressing force F_1 and the pressing force F_2 is changed in various patterns, the distribution of polishing pressures on the semiconductor wafer 4 over its peripheral portion and inner region is also changed in various patterns.

As shown in FIG. 2A, when the pressing force F_1 is larger than the pressing force F_2 ($F_1>F_2$), the polishing pressure applied to the peripheral portion of the semiconductor wafer 4 is larger than the polishing pressure applied to the inner region of the semiconductor wafer 47 so that the amount of a material removed from the peripheral portion of the semiconductor wafer 4 is larger than the amount of a material removed from the inner region of the semiconductor wafer 4 while the semiconductor wafer 4 is being polished.

As shown in FIG. 2B, when the pressing force F_1 is substantially equal to the pressing force F_2 ($F_1 \approx F_2$), the distribution of polishing pressures is continuous and uniform from the center of the semiconductor wafer 4 to its peripheral edge and further to the outer circumferential edge of the presser ring 3, so that the amount of a material removed from the semiconductor wafer 4 is uniform from the peripheral edge to the inner region of the semiconductor wafer 4 while the semiconductor wafer 4 is being polished.

As shown in FIG. 2C, when the pressing force F_1 is smaller than the pressing force F_2 ($F_1<F_2$), the polishing pressure applied to the peripheral portion of the semiconductor wafer 4 is smaller than the polishing pressure applied to the inner region of the semiconductor wafer 4, so that the amount of a material removed from the peripheral edge of the semiconductor wafer 4 is smaller than the amount of a material removed from the inner region of the semiconductor wafer 4 while the semiconductor wafer 4 is being polished.

The pressing force F, and the pressing force F_2 can be changed independently of each other before polishing or during polishing.

As described above, according to the present invention, pressurized fluid is ejected from the holding surface of the top ring 1. At this time, the areas from which the pressurized fluid is ejected are suitably selected, and the pressing force applied to the semiconductor wafer 4 by the pressurized fluid is changed in the central portion and the outer circumferential portion of the semiconductor wafer 4, respectively, during polishing.

In parallel with the above process, the pressing force F_2 of the presser ring 3 disposed around the top ring 1 is determined on the basis of the pressing force F_1 of the top ring 1, and the semiconductor wafer 4 is polished while pressing the polishing cloth 6 by the presser ring 3 under the pressing force F_2 which has been determined. Further, the pressing force F_2 is determined on the basis of the pressure distribution which is applied to the semiconductor wafer 4 by the pressurized fluid, and the semiconductor wafer 4 is polished by a combination of an action caused by the pressurized fluid and an action caused by the presser ring 3. In this manner, insufficient polishing action in thus localized area (for example, the central area or the outer circumferential area) of the semiconductor wafer can be corrected, and the localized area of the semiconductor wafer is prevented from being polished excessively or insufficiently. In the case where the polishing pressure applied to the central portion of the semiconductor wafer 4 is made larger than the outer

circumferential portion of the semiconductor wafer 4 by supplying the pressurized fluid, the pressing force F_2 of the presser ring 3 is made larger than the pressing force F_1 of the top ring 1. Conversely, in the case where the polishing pressure applied to the outer circumferential portion of the semiconductor wafer 4 is made larger than the central portion of the semiconductor wafer 4 by supplying the pressurized fluid, the pressing force F_2 of the presser ring 3 is made smaller than the pressing force F_1 of the top ring 1.

FIGS. 3A through 3C show the results of an experiment in which a semiconductor wafer was polished based on the basic principles of supply of pressurized fluid according to the present invention. The semiconductor wafer used in the experiment was an 8-inch semiconductor wafer. In the experiment, the pressing force (polishing pressure) applied to the semiconductor wafer by the top ring was a constant level of 400 gf/cm^2, and the supply of the pressurized fluid was controlled. FIG. 3A shows the case in which the pressurized fluid was not supplied. FIG. 3B shows the case in which the pressurized fluid is supplied only to the first chamber C_1, and FIG. 3C shows the case in which the pressurized fluid is supplied only to the third chamber C_3. The pressure of the pressurized fluid was 200 gf/cm^2. In each of FIGS. 3A through 3C, the horizontal axis represents a distance(mm) from the center of the semiconductor wafer, and the vertical axis represents a thickness (Å) of a material removed from a semiconductor wafer.

As shown in FIGS. 3A through 3C, the thickness of the removed material at the radial positions on the semiconductor wafer is affected by controlling the supply of the pressurized fluid. Specifically, when the pressurized fluid was not supplied, as shown in FIG. 3A, the peripheral portion of the semiconductor wafer was excessively polished. When the pressurized fluid is supplied only to the first chamber C_1 to press only the central portion of the semiconductor wafer by the pressurized fluid, as shown in FIG. 3B, the peripheral portion of the semiconductor wafer was not excessively polished and the central portion of the semiconductor wafer was slightly excessively polished. When the pressurized fluid was supplied only to the third chamber C_3 to press only the outer circumferential portion of the semiconductor wafer by the pressurized fluid, as shown in FIG. 3C, the outer circumferential portion of the semiconductor wafer was excessively polished and the central portion of the semiconductor wafer was polished insufficiently.

As described above, the experimental result shown in FIGS. 3A through 3E indicate that the amount of the material removed from the localized area of the semiconductor wafer can be adjusted by controlling supply of the pressurized fluid.

FIGS. 4A through 4E show the results of an experiment in which a semiconductor wafer was polished based on the basic principles of the present invention. The semiconductor wafer used in the experiment was an 8-inch semiconductor wafer. In the experiment, the pressing force (polishing pressure) applied to the semiconductor wafer by the top ring was a constant level of 400 gf/cm^2, and the pressing force applied by the presser ring was changed from 600 to 200 gf/cm^2 successively by decrements of 100 gf/cm^2. Specifically, the pressing force applied by the presser ring was 600 gf/cm^2 in FIG. 4A, 500 gf/cm^2 in FIG. 4B, 400 gf/cm^2 in FIG. 4C, 300 gf/cm^2 in FIG. 4D, and 200 gf/cm^2 in FIG. 4E. In each of FIGS. 4A through 4E, the horizontal axis represents a distance (mm) from the center of the semiconductor wafer, and the vertical axis represents a thickness (Å) of a material removed from the semiconductor wafer.

As shown in FIGS. 4A through 4E, the thickness of the removed material at the radial positions on the semiconductor wafer is affected when the pressing force applied by the presser ring was changed. Specifically, when the pressing force applied by the presser ring was in the range from 200 to 300 gf/cm^2 as shown in FIGS. 4D and 4E, the peripheral portion of the semiconductor wafer was excessively polished. When the pressing force applied by the presser ring was in the range from 400 to 500 gf/cm^2, as shown in FIGS. 4B and 4C, the peripheral portion of the semiconductor wafer is substantially equally polished from the peripheral edge to the inner region of the semiconductor wafer. When the pressing force applied by the presser ring was 600 gf/cm$^2{}_1$ as shown in FIG. 4A, the peripheral portion of the semiconductor wafer was polished insufficiently.

The experimental results shown in FIGS. 4A through 4E indicate that the amount of the material removed from the peripheral portion of the semiconductor wafer can be adjusted by varying the pressing force applied by the presser ring independently of the pressing force applied by the top ring. From a theoretical standpoint, the peripheral portion of the semiconductor wafer should be polished optimally when the pressing force applied by the presser ring is equal to the pressing force applied by the top ring. However, since the polishing action depends on the type of the semiconductor wafer and the polishing conditions, the pressing force applied by the presser ring is selected to be of an optimum value based on the pressing force applied by the top ring depending on the type of the semiconductor wafer and the polishing conditions.

There are demands for the removal of a larger or smaller thickness of material from the peripheral portion of the semiconductor wafer than from the inner region of the semiconductor wafer depending on the type of the semiconductor wafer. To meet such demands, the pressing force applied by the presser ring is selected to be of an optimum value based on the pressing force applied by the top ring to intentionally increase or reduce the amount of the material removed from peripheral portion of the semiconductor wafer.

FIGS. 5 through 7 show a polishing apparatus according to a first embodiment of the present invention.

As shown in FIGS. 5 and 6, a top ring 1 has therein a circular first chamber C_1 at a central position thereof, an annular second chamber C_2 disposed at a radially outer side of the first chamber C_1, and an annular third chamber C_3 disposed at a radially outer side of the first chamber C_2. The first chamber C_1 is connected to a compressed air source 24 as a pressurized fluid source through a valve V_1 and a regulator R_1, the second chamber C_2 is connected to the compressed air source 24 through a valve V_2 and a regulator R_2, and the third chamber C_3 is connected to the compressed air source 24 through a valve V_3 and a regulator R_3. The top ring 1 has a recess 1*a* defined in a lower surface thereof for accommodating therein a semiconductor wafer 4 which is a workpiece to be polished. An elastic pad 2 of polyurethane or the like is attached to the lower surface of the top ring 1.

The top ring 1 and the elastic pad 2 have a plurality of openings 1*o* and 2*o*, respectively, which are in registry with each other. Each of the openings 1*o* and 2*o* is communicated with any one of the first chamber C_1, the second chamber C_2, and the third chamber C_3. That is, a plurality of openings each comprising the openings 1*o* and 2*o* for ejecting pressurized fluid are defined on a holding surface of the top ring 1 for holding the semiconductor wafer 4 to be polished. Thus, three concentric annular areas A_1, A_2 and A_3 are

defined in the holding surface of the top ring 1 by allowing the openings 1*o* and 2*o* to be communicated with any one of the first, second and third chambers C_1, C_2 and C_3. The compressed air having different pressure from one another can be supplied to respective annular areas A_1, A_2 and A_3. Pressure gages or pressure sensors G_1, G_2 and G_3 are provided in the respective pressurized fluid supply lines, and the pressure in the respective chambers C_1, C_2 and C_3 can be independently controlled on the basis of the pressures detected by the pressure gages G_1, G_2 and G_3.

A presser ring **3** is disposed around the top ring **1** and is vertically movable with respect to the top ring **1**. A turntable **5** with a polishing cloth **6** attached to an upper surface thereof is disposed below the top ring **1**.

The top ring **1** is connected to a vertical top ring shaft **8** whose lower end is held against a ball **7** mounted on an upper surface of the top ring **1**. The top ring shaft **8** is operatively coupled to a top ring air cylinder **10** fixedly mounted on an upper surface of a top ring head **9**. The top ring shaft **8** is vertically movable by the top ring air cylinder **10** to press the semiconductor wafer **4** supported on the elastic pad **2** against the polishing cloth **6** on the turntable **5**.

The top ring shaft **8** has an intermediate portion extending through and corotatably coupled to a rotatable cylinder **11** by a key (not shown), and the rotatable cylinder **11** has a pulley **12** mounted on outer circumferential surface thereof. The pulley **12** is operatively connected by a timing belt **13** to a timing pulley **15** mounted on the rotatable shaft of a top ring motor **14** which is fixedly mounted on the top ring head **9**. Therefore, when the top ring motor **14** is energized, the rotatable cylinder **11** and the top ring shaft **8** are integrally rotated through the timing pulley **15**, the timing belt **13** and the timing pulley **12**. Thus the top ring **1** is rotated. The top ring head **9** is supported by a top ring head shaft **16** which is vertically fixed on a frame (not shown).

The presser ring **3** is corotatably, but vertically movably, coupled to the top ring **1** by a key **18**. The presser ring **3** is rotatably supported by a bearing **19** which is mounted on a bearing holder **20**. The bearing holder **20** is connected by vertical shafts **21** to a plurality of (three in this embodiment) circumferentially spaced presser ring air cylinders **22**. The presser ring air cylinders **22** are secured to a lower surface of the top ring head **9**.

The top ring air cylinder **10** and the presser ring air cylinders **22** are pneumatically connected to the compressed air source **24** through regulators R_4 and R_5, respectively. The regulator R_4 regulates an air pressure supplied from the compressed air source **24** to the top ring air cylinder **10** to adjust the pressing force which is applied by the top ring **1** to press the semiconductor wafer **4** against the polishing cloth **6**. The regulator R_5 also regulates the air pressure supplied from the compressed air source **24** to the presser ring air cylinder **22** to adjust the pressing force which is applied by the presser ring **3** to press the polishing cloth **6**. The regulators R_4 and R_5 are controlled by a controller (not shown in FIG. 5).

An abrasive liquid supply nozzle **25** is positioned above the turntable **5** for supplying an abrasive liquid Q onto the polishing cloth **6** on the turntable **5**.

As shown in FIG. **6**, the top ring **1** has an outer circumferential annular flange 1*s* extending downwardly toward the turntable **5**. The lower surface of the top ring **1** and the annular flange is jointly define a recess 1*a* for accommodating the semiconductor wafer **4** therein.

The polishing apparatus shown in FIGS. **5**, **6** and **7** operates as follows: The semiconductor wafer **4** to be

polished is placed in the recess 1*a* and held against the elastic pad 2, and the top ring air cylinder 10 is actuated to lower the top ring 1 toward the turntable 5 until the semiconductor wafer 4 is pressed against the polishing cloth 6 on the upper surface of the rotating turntable 5. The top ring 1 and the presser ring 3 are rotated by the top ring motor 14 through the top ring shaft 8. Since the abrasive liquid Q is supplied onto the polishing cloth 6 by the abrasive liquid supply nozzle 25, the abrasive liquid Q is retained on the polishing cloth 6. Therefore, the lower surface of the semiconductor wafer 4 is polished with the abrasive liquid Q which is present between the lower surface of the semiconductor wafer 4 and the polishing cloth 6.

During polishing, compressed air is supplied from the compressed air source 24 to the first, second and third chambers C_1, C_2 and C_3 selectively, and the supplied compressed air is ejected from the lower surface of the elastic pad 2 through the openings 1*o* and 2*o*, and is supplied between the holding surface of the top ring 1 and the upper surface of the semiconductor wafer 4. At this time, at least one of the chambers C_1, C_2 and C_3 to which compressed air is supplied is selected, and at least one of the annular areas A_1, A_2 and A_3 from which compressed air is ejected is selected. For example, compressed air is supplied only to the first chamber C_1, and is not supplied to the second and third chambers C. and C_3, whereby the semiconductor wafer 4 is pressed against the polishing cloth 6 by the compressed air in such a state that the polishing pressure applied to the central portion of the semiconductor wafer 4 is larger than the polishing pressure applied to outer circumferential portion of the semiconductor wafer 4. Thus, if the amount of a material removed from the outer circumferential portion of the semiconductor wafer 4 is larger than the amount of a material removed from the central portion of the semiconductor wafer 4, insufficient polishing action at the central portion of the semiconductor wafer can be corrected by utilizing the pressing action of the pressurized fluid.

On the other hand, if the amount of a material removed from the central portion of the semiconductor wafer 4 is larger than the amount of a material removed from the outer circumferential portion of the semiconductor wafer 4, the compressed air is supplied only to the third chamber C_3, and is not supplied to the first and second chambers C_1 and C_2, whereby the polishing pressure applied to the outer circumferential portion of the semiconductor wafer 4 is larger than the polishing pressure applied to the central portion of the semiconductor wafer 4. Thus, insufficient polishing action at the outer circumferential portion of the semiconductor wafer can be corrected, and the entire surface of the semiconductor wafer 4 can be uniformly polished.

The pressures of compressed air supplied to the first chamber C_1, the second chamber C_2 and the third chamber C_3 are changed respectively, that is, compressed air having a pressure of p_1 gf/cm^2 is supplied to the first chamber C_1, compressed air having a pressure of P_2 gf/cm^2 is supplied to the second chamber C_2, and compressed air having a pressure of p_3 gf/cm^2 is supplied. In this manner, the compressed air which is supplied between the holding surface of the top ring 1 and the upper surface of the semiconductor wafer 4 has pressure gradient so as to be higher or lower progressively from the central area to the outer circumferential area of the semiconductor wafer 4. That is, the pressing force for pressing the semiconductor wafer 4 against the polishing cloth 6 has gradient from the central area to the outer circumferential area of the semiconductor wafer 4. Thus, irregularities of the polishing action can be sufficiently corrected and the localized area of the semiconductor wafer 4 is prevented from being polished excessively or insufficiently.

Further, in the present invention, depending on the pressing force applied by the top ring 1 actuated by the top ring air cylinder 10, the pressing force applied to the polishing cloth 6 by the presser ring 3 actuated by the presser ring air cylinders 22 is adjusted while the semiconductor wafer 4 is being polished. During the polishing process, the pressing force F_1 (see FIG. 1) which is applied by the top ring 1 to press the semiconductor wafer 4 against the polishing cloth 6 can be adjusted by the regulator R_1, and the pressing force F_2 which is applied by the presser ring 3 to press the polishing cloth 6 can be adjusted by the regulator R_2. Therefore, during the polishing process, the pressing force F_2 applied by the presser ring 3 to press the polishing cloth 6 can be changed depending on the pressing force F_1 applied by the top ring 1 to press the semiconductor wafer 4 against the polishing cloth 6. By adjusting the pressing force F_2 with respect to the pressing force F_1, the distribution of polishing pressures is made continuous and uniform from the center of the semiconductor wafer 4 to its peripheral edge and further to the outer circumferential edge of the presser ring 3 disposed around the semiconductor wafer 4. Consequently, the peripheral portion of the semiconductor wafer 4 is prevented from being polished excessively or insufficiently. The semiconductor wafer 4 can thus be polished to a high quality and with a high yield.

If a larger or smaller thickness of material is to be removed from the peripheral portion of the semiconductor wafer 4 than from the inner region of the semiconductor wafer 4, then the pressing force F_2 applied by the presser ring 3 is selected to be of a suitable value based on the pressing force F_1 applied by the top ring 1 to intentionally increase or reduce the amount of a material removed from the peripheral portion of the semiconductor wafer 4.

By controlling compressed air supplied to the first, second and third chambers C_1, C_2 and C_3, the semiconductor wafer 4 is polished by a combination of a pressing action caused by the compressed air and a pressing action caused by the presser ring 3. Thus, insufficient polishing action in the localized area (for example, the central area or the outer circumferential area) of the semiconductor wafer can be corrected. Further, the amount of the material removed from the localized areas (for example, the central area or the outer circumferential area) can be intentionally increased or decreased. In this case, in the case where the polishing pressure at the central portion of the semiconductor wafer 4 is made larger than the polishing pressure at the outer circumferential portion of the semiconductor wafer 4, the pressing force F_2 of the presser ring 3 is made larger than the pressing force F_1 of the top ring 1. Conversely, in the case where the polishing pressure at the outer circumferential portion of the semiconductor wafer 4 is made larger than the polishing pressure at the central portion of the semiconductor wafer 4, the pressing force F_2 of the presser ring 3 is made smaller than the pressing force F_1 of the top ring 1.

In this embodiment, since the semiconductor wafer 4 is accommodated in the recess 1*a* of the top ring 1 and protected by the annular flange 1*s*, the outer circumferential surface of the semiconductor wafer 4 at its peripheral edge is not rubbed by the presser ring 3 when the presser ring 3 is vertically moved with respect to the top ring 1. Therefore, the presser ring 3 as it is vertically moved with respect to the top ring 1 does not adversely affect the polishing performance of the polishing apparatus during the polishing process.

FIG. 8 shows a polishing apparatus according to a second embodiment of the present invention. As shown in FIG. 8, a top ring 51 comprises a main body 52 and a ring member

54 detachably fixed by bolts 53 to a lower outer circumferential surface of the main body 52. The top ring 51 has a recess 51*a* for accommodating the semiconductor wafer 4. The recess 51*a* is defined by a lower surface of the main body 52 and an inner circumferential surface of the ring member 54. The semiconductor wafer 4 accommodated in the recess 51*a* has an upper surface held by the lower surface of the main body 52 and an outer circumferential surface held by the inner circumferential surface of the ring member 54. The presser ring 3 is vertically movably disposed around the top ring 51.

The main body 52 of the top ring 51 has therein a circular first chamber C_1 at a central position thereof. an annular second chamber C_2 disposed at a radially outer side of the first chamber C_1. and an annular third chamber C_3 disposed at a radially outer side of the first chamber C_2. The first chamber C_1. the second chamber C_2 and the third chamber C_3 are connected to the compressed air source (not shown) to allow compressed air to be supplied thereto in the same manner as the embodiment in FIGS. 5 through 7. The main body 52 of the top ring 51 has a plurality of openings 52*o* which are communicated with the first chamber C_1. the second chamber C_2 and the third chamber C_3. respectively. An elastic pad 2 also has a plurality of openings 2*o* which are in registry with the openings 52*o*. Thus compressed air can be applied to the upper surface of the semiconductor wafer 4.

While the workpiece to be polished according to the present invention has been illustrated as a semiconductor wafer. it may be a glass product. a liquid crystal panel. a ceramic product. etc. Further. as pressurized fluid. pressurized liquid may be used. The top ring and the presser ring may be pressed by hydraulic cylinders rather than the illustrated air cylinders. The presser ring may be pressed by electric devices such as piezoelectric or electromagnetic devices rather than the illustrated purely mechanical devices.

As described above. the present invention offers the following advantages:

The distribution of the pressing force of the workpiece is prevented from being nonuniform at the peripheral portion of the workpiece during the polishing process. and the polishing pressures can be uniformized over the entire surface of the workpiece. Therefore. the peripheral portion of the semiconductor wafer is prevented from being polished excessively or insufficiently. The entire surface of workpiece can thus be polished to a flat mirror finish. In the case where the present invention is applied to semiconductor manufacturing processes. the semiconductor devices can be polished to a high quality. Since the peripheral portion of the semiconductor wafer can be used as products. yields of the semiconductor devices can be increased.

In the case where there are demands for she removal of a larger or smaller thickness of material from the peripheral portion of the semiconductor wafer than from the inner region of the semiconductor wafer depending on the type of the semiconductor wafer. the amount of the material removed from the peripheral portion of the semiconductor wafer can be intentionally increased or decreased. Further. the amount of the material removed from not only the peripheral portion of the semiconductor wafer but also the localized area (for example. central portion or outer circumferential portion) can be intentionally increased or decreased.

Although certain preferred embodiments of the present invention have been shown and described in detail. it should

be understood that various changes and modifications may be made therein without departing from the scope of the appended claims.

What is claimed is:

1. A polishing apparatus for polishing a surface of a workpiece comprising:

a turntable having a polishing surface thereon;

a top ring for supporting the workpiece to be polished and pressing the workpiece against said polishing surface under a first pressing force, said top ring having a holding surface for holding the workpiece;

a pressurized fluid source for supplying pressurized fluid;

a plurality of openings provided in said holding surface of said top ring for ejecting said pressurized fluid supplied from said pressurized fluid source, a plurality of areas each having said openings being defined in said holding surface so that said pressurized fluid is selectively ejectable from said openings in said respective areas.

2. An apparatus according to claim 1, wherein said plurality of areas comprises concentric annular areas.

3. An apparatus according to claim 1, wherein said plurality of areas are defined by communicating with a plurality of chambers, respectively formed in said top ring through said openings.

4. An apparatus according to claim 1, wherein said first pressing force and a pressure of said pressurized fluid are variable independently of each other.

5. An apparatus according to claim 1, wherein a pressure of said pressurized fluid is variable in each of said areas.

6. An apparatus according to claim 1, further comprising:

a presser ring vertically movably disposed around said top ring; and

a pressing device for pressing said presser ring against said polishing surface under a second pressing force which is variable.

7. An apparatus according to claim 1, wherein said top ring has a recess defined therein for accommodating the workpiece therein.

8. A method of polishing a workpiece, comprising the steps of:

holding a workpiece between a polishing surface of a turntable and a holding surface of a top ring disposed above said turntable;

pressing the workpiece by said top ring against said polishing surface under a first pressing force; and

ejecting pressurized fluid from openings in a plurality of areas in said holding surface of said top ring toward the workpiece held by said top ring, said pressurized fluid being selectively ejectable from said openings in said respective areas; and

polishing the workpiece in such a state that a pressing force applied to the workpiece by said pressurized fluid is variable in a central portion and an outer circumferential portion of the workpiece, respectively.

9. A method according to claim 8, further comprising the step of:

pressing a presser ring vertically movably disposed around said top ring against said polishing surface around the workpiece under a second pressing force which is determined based on said first pressing force.

10. A method according to claim 8, said second pressing force is determined on the basis of a pressure distribution on the workpiece caused by said pressurized fluid ejected from said openings in said respective areas.

11. A top ring for supporting the workpiece to be polished, for use in a polishing apparatus, comprising:

a holding surface for holding the workpiece; and

a plurality of openings, provided in said holding surface, from which pressurized fluid is ejected, a plurality of areas each having said openings being defined in said holding surface so that said pressurized fluid is selectively ejectable from said openings in said respective areas.

12. A method of polishing a surface of a workpiece, comprising:

holding a workpiece by a top ring; and

pressing the workpiece against a polishing surface of a turntable to polish a surface of the workpiece by applying independently adjustable pressures to substantially concentric circular areas of the workpiece, respectively.

13. A method according to claim 12, wherein said pressure is produced by air pressure.

14. A method according to claim 12, further comprising applying an adjustable pressure to a presser ring vertically movably disposed around said top ring for pressing said polishing surface.

15. A method according to claim 14, wherein said pressure applied to said presser ring is produced by air pressure.

16. A method according to claim 12, wherein the pressure applied to a central portion of the workpiece is larger than the pressure applied to an outer circumferential portion of the workpiece.

17. A method according to claim 12, wherein the pressure applied to an outer circumferential portion of the workpiece is larger than the pressure applied to a central portion of the workpiece.

18. A method of polishing a surface of a workpiece, comprising:

holding a workpiece by a top ring; and

pressing the workpiece against a polishing surface of a turntable to polish a surface of the workpiece so that an annular area of said workpiece is selectively pressed.

19. A method according to claim 18, wherein said annular area of said workpiece is an outer circumferential portion of said workpiece.

20. A method according to claim 18, further comprising applying a pressure to a presser ring vertically movably disposed around said top ring for pressing said polishing surface.

21. A method according to claim 18, wherein each of said pressures applied to the workpiece and said presser ring is produced by air pressure.

22. A method of polishing a surface of a workpiece, comprising:

holding a workpiece by a top ring;

pressing the workpiece against a polishing surface of a turntable so that a polishing pressure applied to a central portion of the workpiece is different from a polishing pressure applied to an outer circumferential portion of the workpiece to polish a surface of the workpiece; and

applying a pressure which is independently variable to a presser ring vertically movably disposed around said top ring for pressing said polishing surface.

23. A method of polishing a surface of a workpiece, comprising:

holding a workpiece by a top ring; and

pressing the workpiece against a polishing surface of a turntable to polish a surface of the workpiece by applying at least two pressures to substantially concentric circular areas of the workpiece, respectively.

24. A method of polishing a surface of a workpiece, comprising:

holding a workpiece by a top ring; and

pressing the workpiece against a polishing surface of a turntable to polish a surface of the workpiece by applying at least two pressures to two chambers configured above a central portion and an outer circumferential portion of the workpiece, respectively.

25. A method of polishing a surface of a workpiece, comprising:

holding a workpiece by a top ring;

pressing the workpiece against a polishing surface of a turntable to polish a surface of the workpiece so that at least two pressures are applied to the workpiece and are different in a central portion and in an outer circumferential portion of the workpiece; and

applying a pressure to a presser ring vertically movably disposed around said top ring by air pressure for pressing said polishing surface.

26. A method of polishing a surface of a workpiece, comprising:

holding a workpiece by a top ring;

applying air pressure to an interior of said top ring so that the polishing pressures applied to the workpiece are different at different radial portions of said workpiece; and

applying a pressure to a presser ring vertically movably disposed around said top ring by air pressure for pressing said polishing surface.

27. A polishing apparatus for polishing a surface of a workpiece comprising:

a turntable having a polishing surface thereon;

a top ring for supporting the workpiece to be polished to polish a surface of the workpiece on said polishing surface.

a presser ring vertically movably disposed around said top ring, said presser ring being movable with respect to said top ring; and

a pressing mechanism for providing polishing pressures on the workpiece by air pressure;

wherein said polishing pressures are different in a central portion and an outer circumferential portion of the workpiece.

28. A polishing apparatus according to claim 27, wherein said pressing force has gradient so as to be higher or lower progressively from the central area to the outer circumferential area of the workpiece.

29. A polishing apparatus according to claim 27, wherein the pressure applied to a central portion of the workpiece is larger than the pressure applied to an outer circumferential portion of the workpiece.

30. A polishing apparatus according to claim 27, wherein the pressure applied to an outer circumferential portion of the workpiece is larger than the pressure applied to a central portion of the workpiece.

31. A polishing apparatus for polishing a surface of a workpiece comprising:

a turntable having a polishing surface thereon;

a top ring for supporting the workpiece to be polished on a holding surface of said top ring and

pressing the workpiece against said polishing surface;

a first pressing device for pressing said top ring against said polishing surface under a first pressing force;

a presser ring vertically movably disposed around said top ring;

a second pressing device for pressing said presser ring against said polishing surface under a second pressing force, said second pressing force being variable with respect to said first pressing force; and

a pressing mechanism for providing a third pressing force onto the workpiece, said third pressing force being different in a central portion and an outer circumferential portion of the workpiece.

32. A polishing apparatus according to claim 31, wherein said pressing force has gradient so as to be higher or lower progressively from the central area to the outer circumferential area of the workpiece.

33. A polishing apparatus according to claim 31, wherein the pressure applied to a central portion of the workpiece is larger than the pressure applied to an outer circumferential portion of the workpiece.

34. A polishing apparatus according to claim 31, wherein the pressure applied to an outer circumferential portion of the workpiece is larger than the pressure applied to a central portion of the workpiece.

35. A polishing apparatus according to claim 31, wherein said pressing mechanism provides said third pressing force by air pressure.

36. A polishing apparatus according to claim 31, wherein said first pressing device and second pressing device provide said first and second pressing forces by air pressure.

37. A polishing apparatus for polishing a surface of a workpiece comprising:

a turntable having a polishing surface thereon;

a top ring for supporting the workpiece to be polished on a holding surface of said top ring;

a pressing mechanism for pressing the workpiece against said polishing surface of said turntable so that a polishing pressure applied to a central portion of the workpiece is different from a polishing pressure applied to an outer circumferential portion of the workpiece to polish a surface of the workpiece; and

a presser ring vertically movably disposed around said top ring, said presser ring being movable with respect to said top ring, and pressed against said polishing surface by air pressure.

F I G. 1

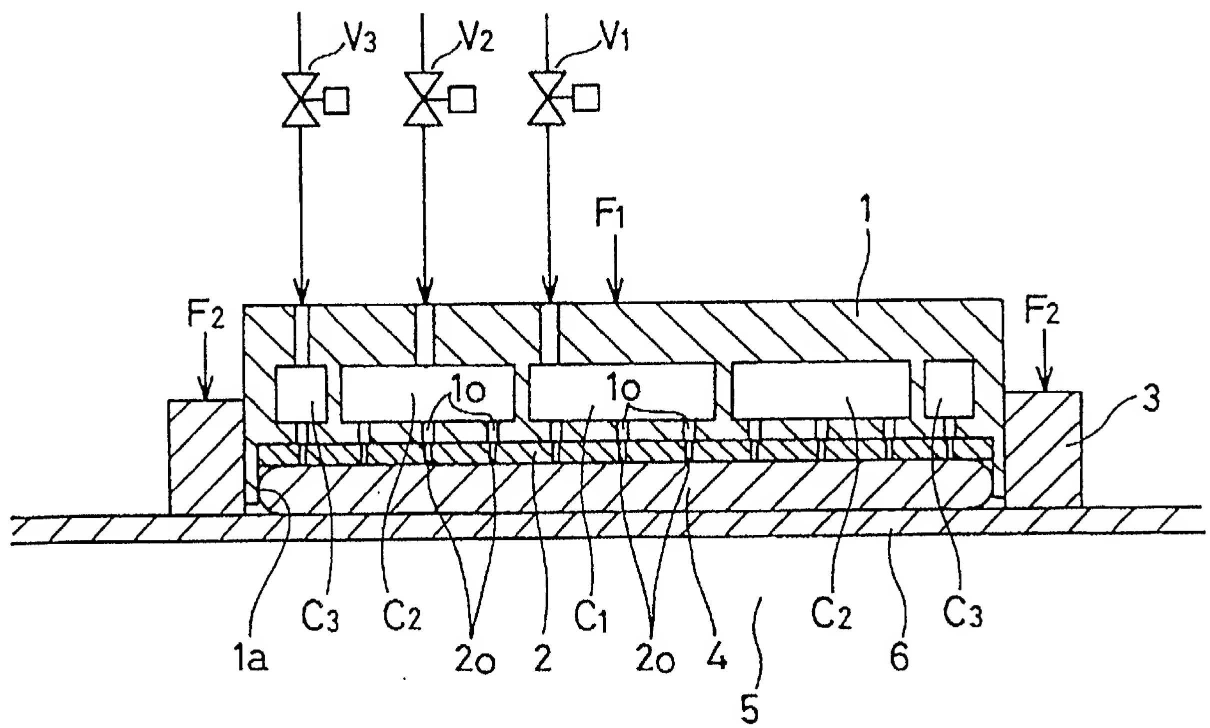


FIG. 2A

$F_1 > F_2$

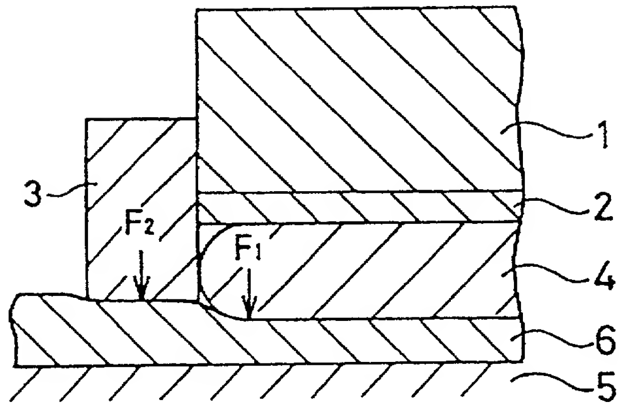


FIG. 2B

$F_1 \fallingdotseq F_2$

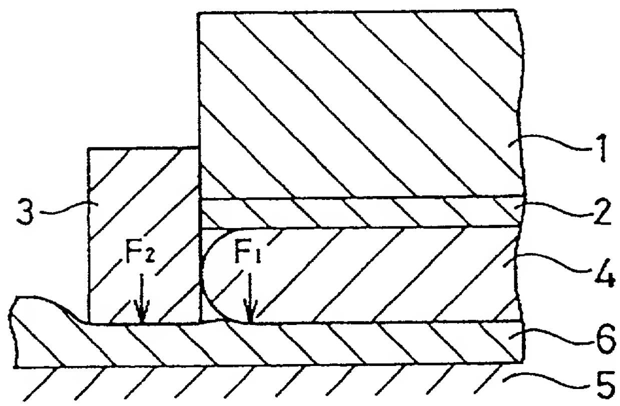
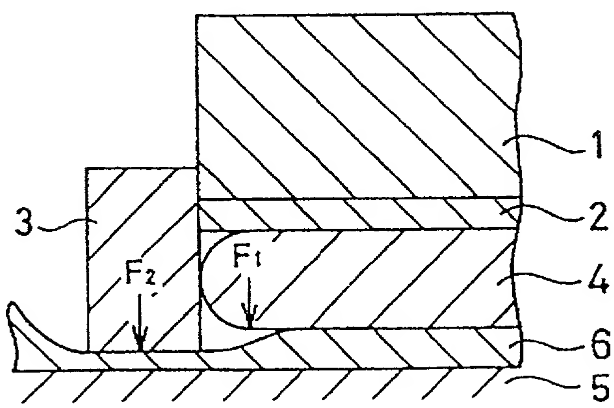
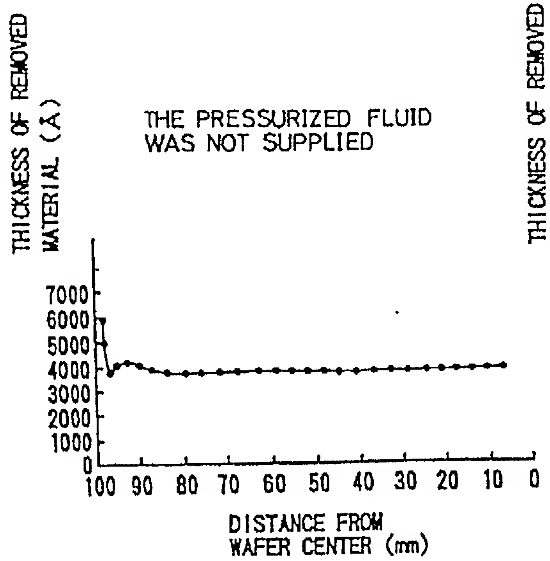


FIG. 2C

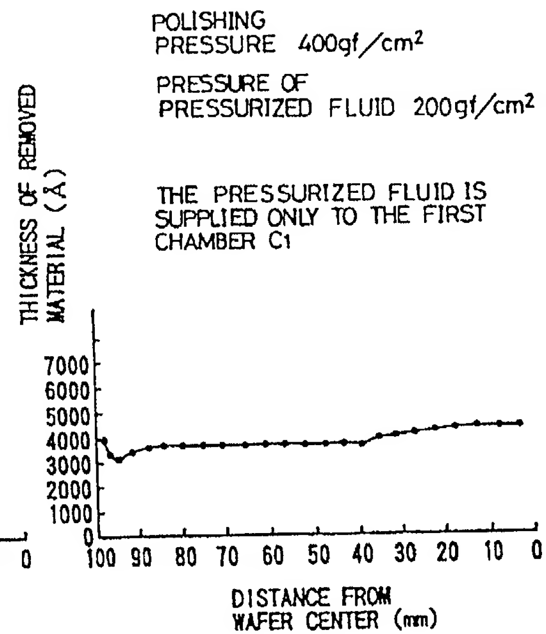
$F_1 < F_2$



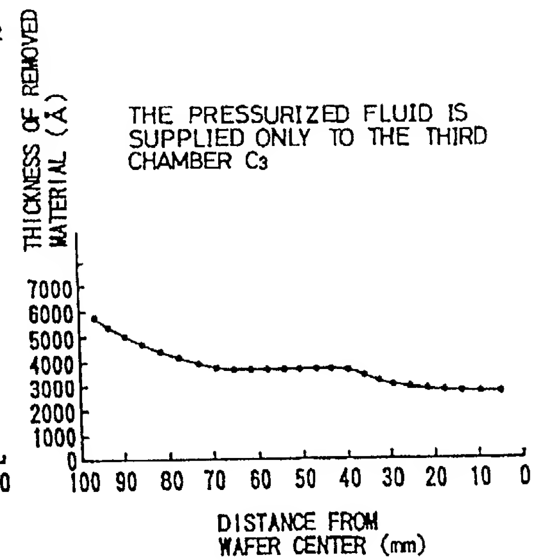
F I G. 3A



F I G. 3B



F I G. 3C



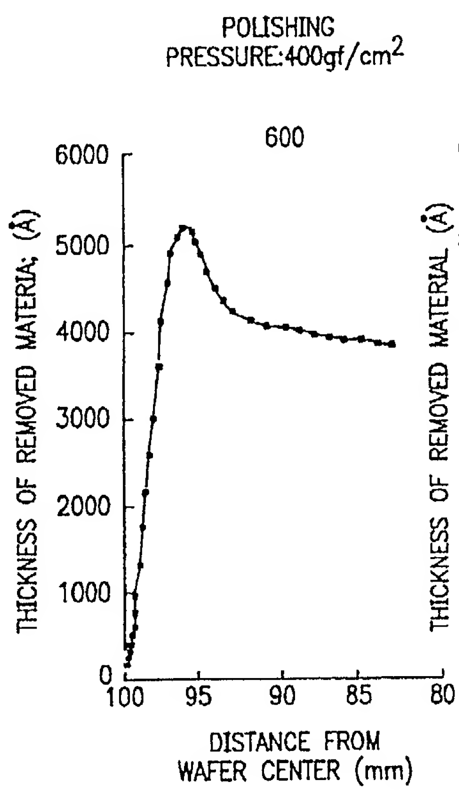


FIG. 4A

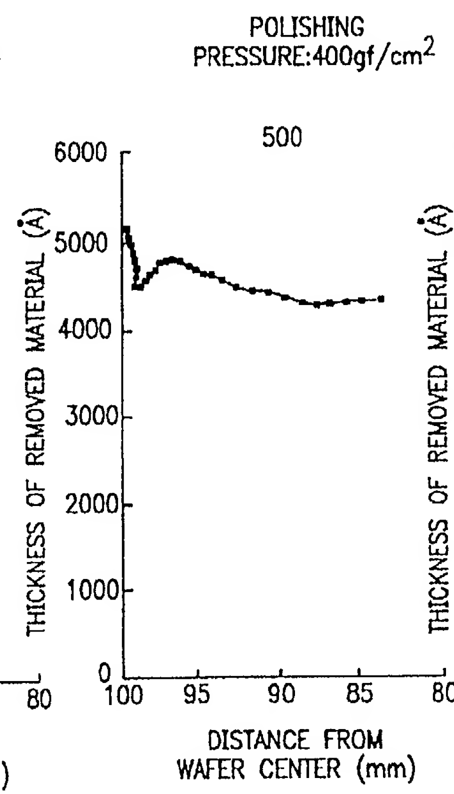


FIG. 4B

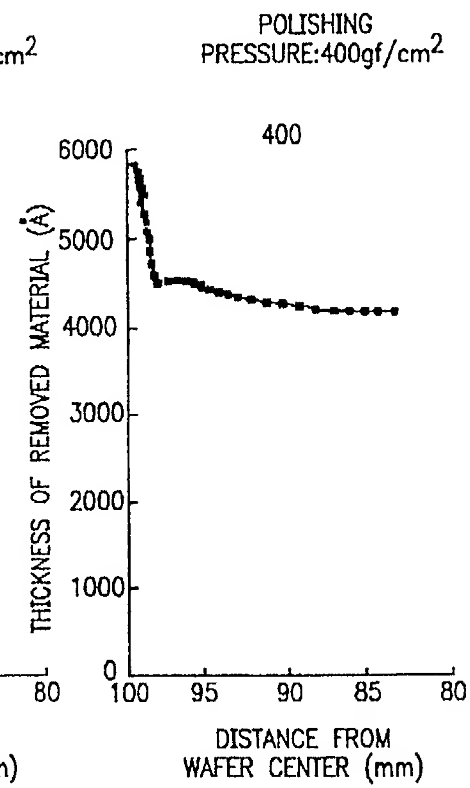


FIG. 4C

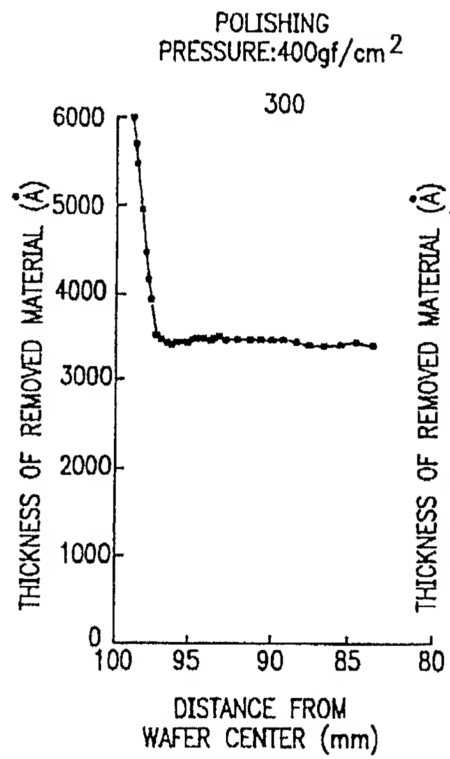

POLISHING
PRESSURE:400gf/cm2
300
THICKNESS OF REMOVED MATERIAL (Å)
6000
5000
4000
3000
2000
1000
0
100
95
90
85
80
DISTANCE FROM
WAFER CENTER (mm)

FIG. 4D

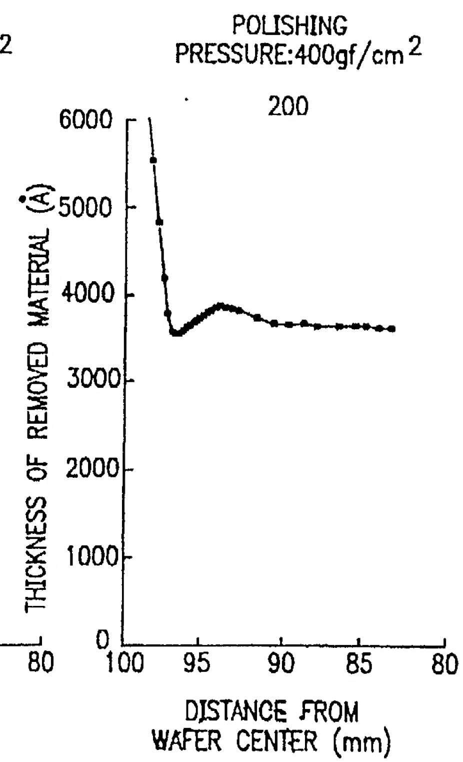
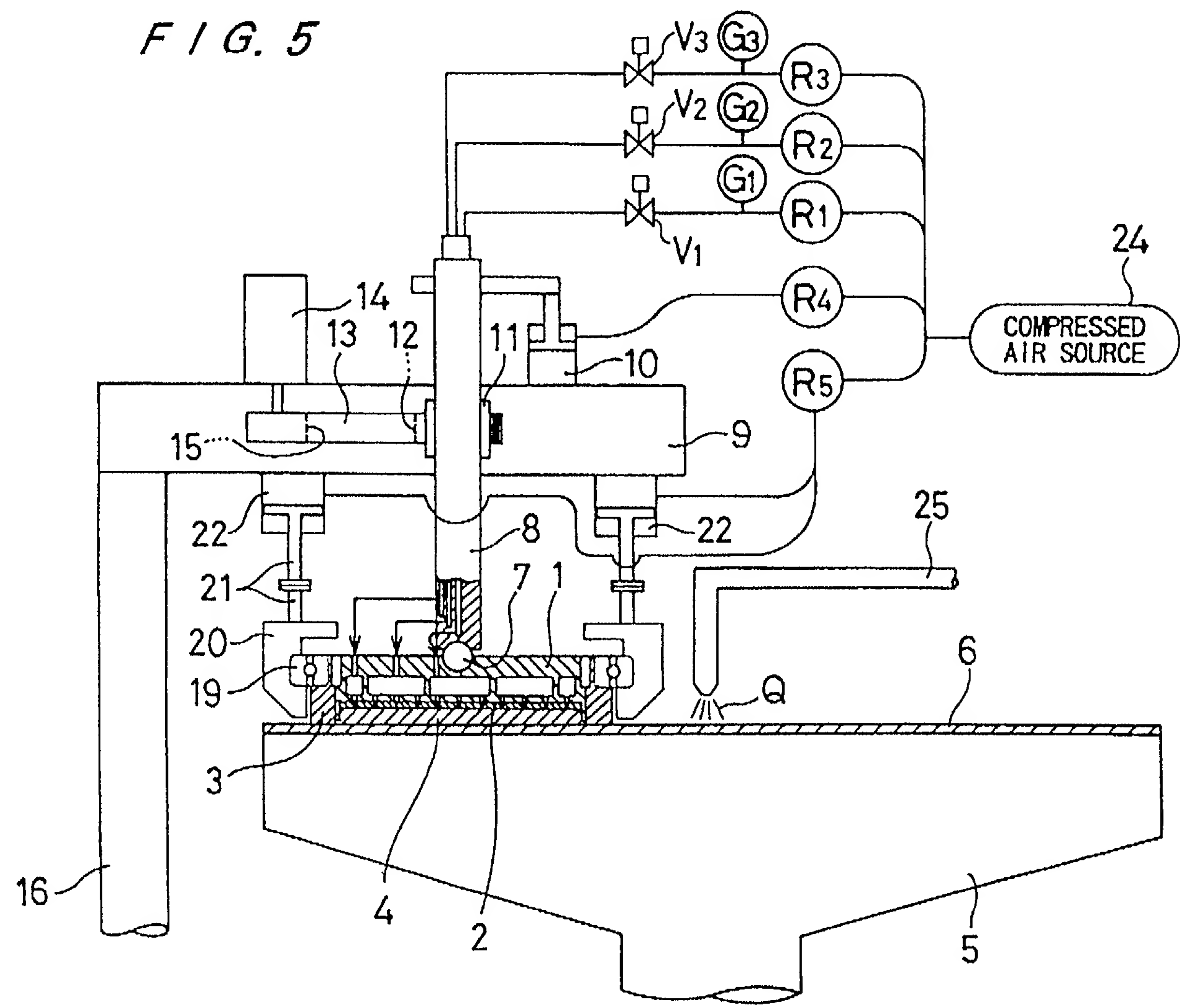

POLISHING
PRESSURE:400gf/cm2
200
THICKNESS OF REMOVED MATERIAL (Å)
6000
5000
4000
3000
2000
1000
0
100
95
90
85
80
DISTANCE FROM
WAFER CENTER (mm)

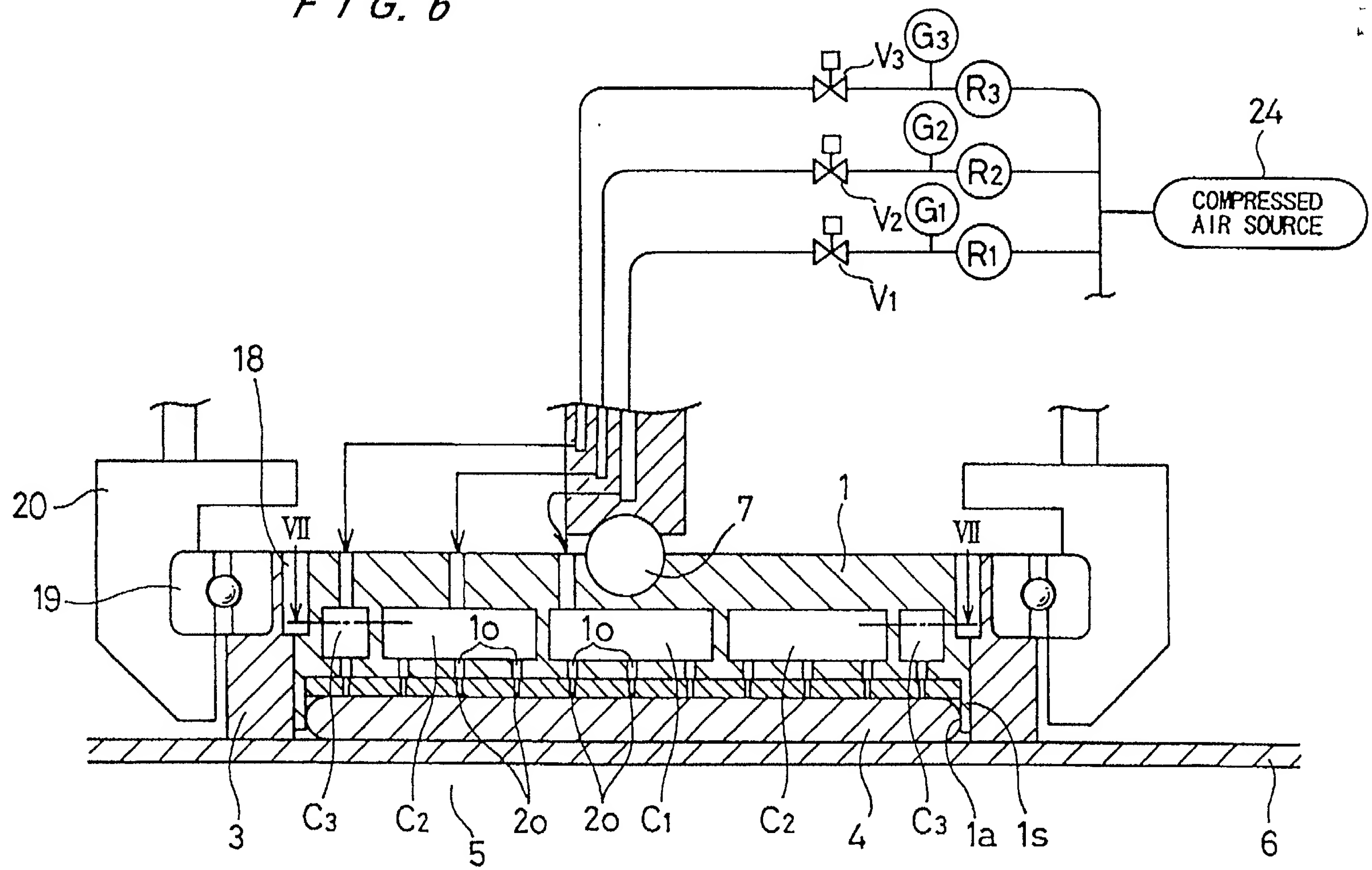
FIG. 4E

008090"88E68560

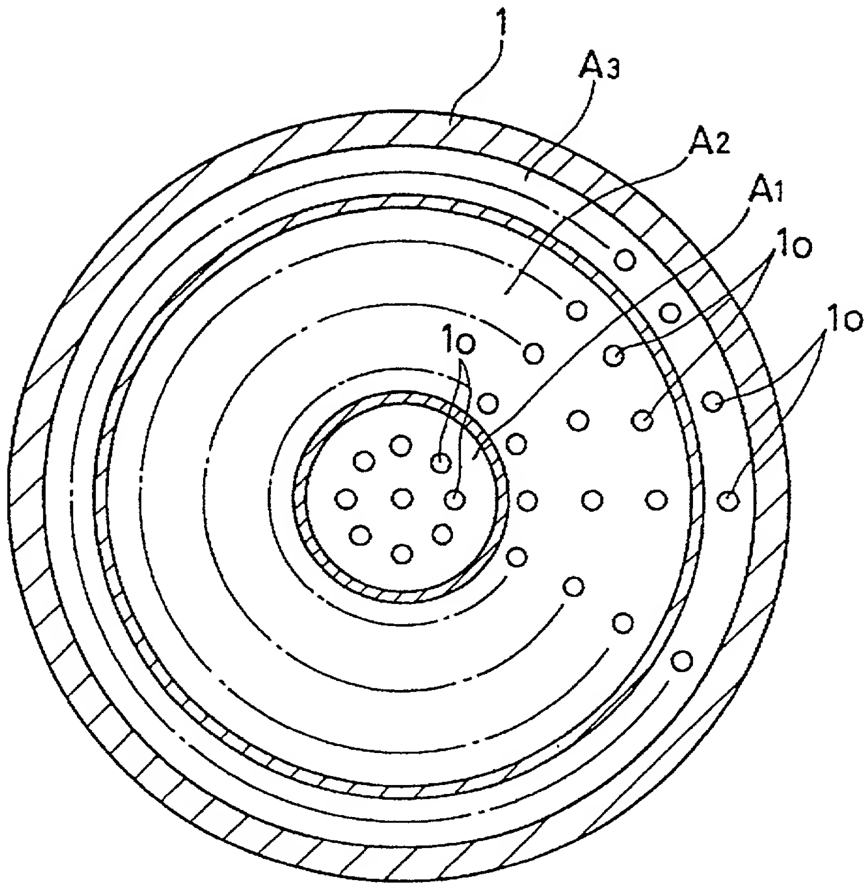
F / G. 5



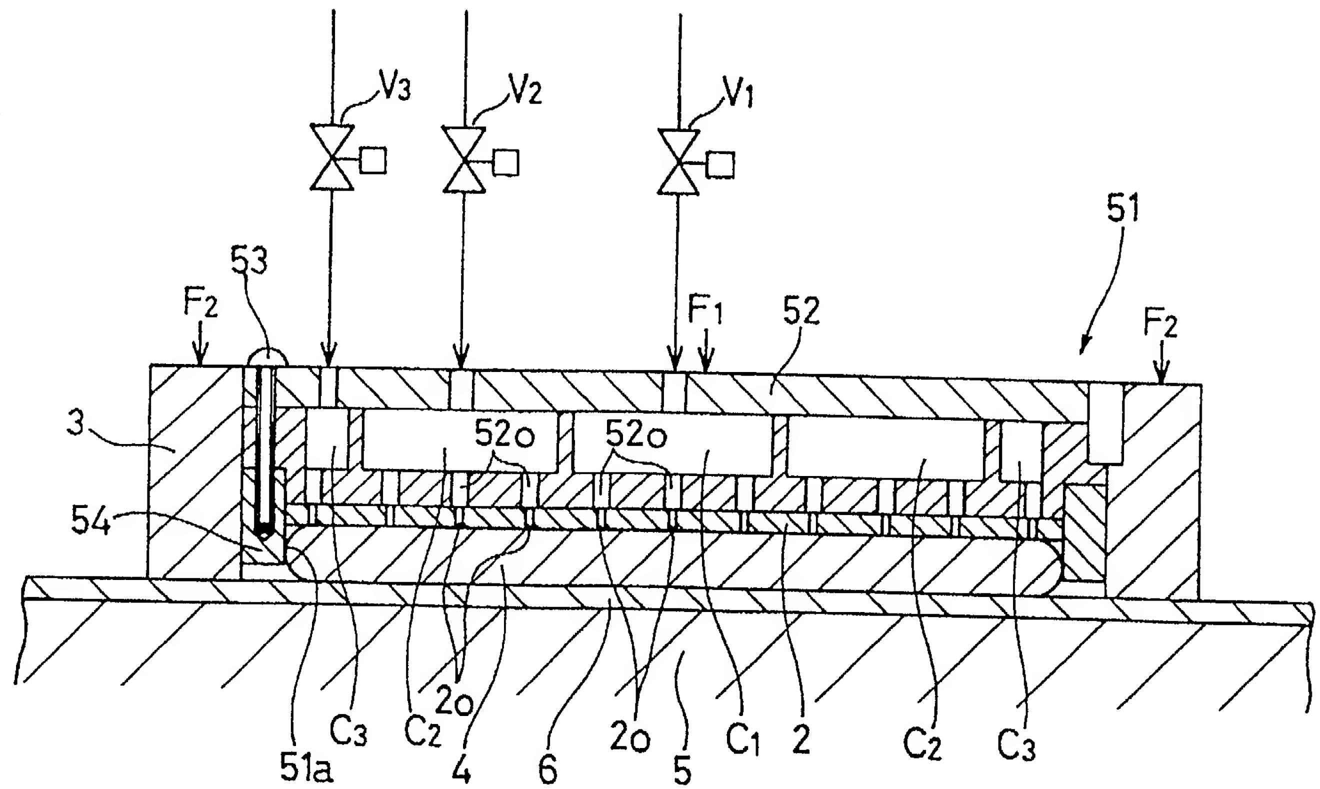
F I G. 6


24
COMPRESSED
AIR SOURCE
G3
R3
V3
G2
R2
V2
G1
R1
V1
18
20
19
VII
VII
7
1
1o
1o
3
C3
C2
5
2o
2o
C1
C2
4
C3
1a
1s
6

F I G. 7



F / G. 8



Rev. 11-3/98

Effective March 1998

DECLARATION AND POWER OF ATTORNEY FOR U.S. PATENT APPLICATION

(X) Original () Supplemental () Substitute () PCT () DESIGN

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Title: APPARATUS FOR AND METHOD FOR POLISHING WORKPIECE

OIPE JC68 SEP 14 2000 PATENT & TRADEMARK OFFICE

of which is described and claimed in:
( ) the attached specification, or
( ) the specification in application Serial No. ____________, filed June 8, 2000 and with amendments through (if applicable), or
( ) the specification in International Application No. , filed , and as amended on (if applicable).
(X) letters patent number 5,762,539 granted on June 9, 1998 and in the attached specification for which I solicit a reissue patent.

I hereby state that I have reviewed and understand the content of the above-identified specification, including the claims, as amended by any amendment(s) referred to above.

I acknowledge my duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim priority benefits under Title 35, United States Code, §119 (and §172 if this application is for a Design) of any application(s) for patent or inventor's certificate listed below and have also identified below any application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NO.	DATE OF FILING	PRIORITY CLAIMED
Japan	65315/1996	February 27, 1996	YES

I believe the original patent to be partly inoperative by reason of the patentee claiming less than patentee had the right to claim in the patent. In particular, in patent claim 1, the limitation of "a pressurized fluid source for supplying pressurized fluid" unnecessarily and unduly restricts the scope of claim 1 in that other aspects of the disclosed invention are patentable without such limitation. Also, patent claim 8 requires that the step of "ejecting pressurized fluid from openings in a plurality of areas in said holding surface of said top ring toward the workpiece held by said top ring, said pressurized fluid being selectively ejectable from said openings in said respective areas". This limitation unnecessarily and unduly restricts the scope of patent claim 8. Applicants consider their invention to include the steps of holding a workpiece by a top ring, and pressing the workpiece against a polishing surface of a turntable to polish a surface of the workpiece by applying independently adjustable pressures to substantially concentric circular areas of the workpiece. Thus, the method recited in patent claim 8 is unnecessarily limited by the inclusion of the limitation of ejecting pressurized fluid from openings in a plurality of areas in the holding surface of the top ring.

All errors which are being corrected in the present reissue application up to the time of filing of this Declaration arose without any deceptive intention on the part of the Applicants.

And I hereby appoint Michael R. Davis, Reg. No. 25,134; Matthew M. Jacob, Reg. No. 25,154; Jeffrey Nolton, Reg. No. 25,408; Warren M. Cheek, Jr., Reg. No. 33,367; Nils Pedersen, Reg. No. 33,145; and Charles R. Watts, Reg. No. 33,142, who together constitute the firm of WENDEROTH, LIND & PONACK, L.L.P., jointly and severally, attorneys to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected therewith.

I hereby authorize the U.S. attorneys named herein to accept and follow instructions from WATANABE & HOTTA as to any action to be taken in the U.S. Patent and Trademark Office regarding this application without direct communication between the U.S. attorneys and myself. In the event of a change in the persons from whom instructions may be taken, the U.S. attorneys named herein will be so notified by me.

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Full Name of Sixth Inventor	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
Residence & Citizenship	CITY	STATE OR COUNTRY	COUNTRY OF CITIZENSHIP	
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I further declare that all statements made herein of my own knowledge are true, and that all statements on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

1st Inventor Masamichi Nakashiba Date July 21, 2000
Masamichi NAKASHIBA

2nd Inventor Norio Kimura Date July 21, 2000
Norio KIMURA

3rd Inventor Isamu Watanabe Date July 21, 2000
Isamu WATANABE

4th Inventor Kaori Yoshida Date July 21, 2000
Kaori YOSHIDA

5th Inventor ______________________ Date ____________

6th Inventor ______________________ Date ____________

The above application may be more particularly identified as follows:

U.S. Application Serial No. ________________ Filing Date June 8, 2000

Applicant Reference Number GEB475-US-Reissue Atty Docket No. 2000-0722

Title of Invention APPARATUS FOR AND METHOD FOR POLISHING WORKPIECE

DECLARATION AND POWER OF ATTORNEY FOR U.S. PATENT APPLICATION

(X) Original () Supplemental () Substitute () PCT () DESIGN

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Title: APPARATUS FOR AND METHOD FOR POLISHING WORKPIECE

of which is described and claimed in:
( ) the attached specification, or
( ) the specification in application Serial No. ____________, filed June 8, 2000, and with amendments through (if applicable), or
( ) the specification in International Application No. , filed , and as amended on (if applicable).
(X) letters patent number 5,762,539 granted on June 9, 1998 and in the attached specification for which I solicit a reissue patent.

I hereby state that I have reviewed and understand the content of the above-identified specification, including the claims, as amended by any amendment(s) referred to above.

I acknowledge my duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim priority benefits under Title 35, United States Code, §119 (and §172 if this application is for a Design) of any application(s) for patent or inventor's certificate listed below and have also identified below any application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NO.	DATE OF FILING	PRIORITY CLAIMED
Japan	65315/1996	February 27, 1996	YES

I believe the original patent to be partly inoperative by reason of the patentee claiming less than patentee had the right to claim in the patent. In particular, in patent claim 1, the limitation of "a pressurized fluid source for supplying pressurized fluid" unnecessarily and unduly restricts the scope of claim 1 in that other aspects of the disclosed invention are patentable without such limitation. Also, patent claim 8 requires that the step of "ejecting pressurized fluid from openings in a plurality of areas in said holding surface of said top ring toward the workpiece held by said top ring, said pressurized fluid being selectively ejectable from said openings in said respective areas". This limitation unnecessarily and unduly restricts the scope of patent claim 8. Applicants consider their invention to include the steps of holding a workpiece by a top ring, and pressing the workpiece against a polishing surface of a turntable to polish a surface of the workpiece by applying independently adjustable pressures to substantially concentric circular areas of the workpiece. Thus, the method recited in patent claim 8 is unnecessarily limited by the inclusion of the limitation of ejecting pressurized fluid from openings in a plurality of areas in the holding surface of the top ring.

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1st Inventor ______________________ Date ____________
Masamichi NAKASHIBA

2nd Inventor ______________________ Date ____________
Norio KIMURA

3rd Inventor ______________________ Date ____________
Isamu WATANABE

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U.S. Application Serial No. ____________ Filing Date June 8, 2000

Applicant Reference Number GEB475-US-Reissue Atty Docket No. 2000-0722

Title of Invention APPARATUS FOR AND METHOD FOR POLISHING WORKPIECE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue application of :

U.S. Patent No. 5,762,539 : Attn: **BOX PATENT APPLICATION**

Issued June 9, 1998 : Docket No. 2000-0722

Masamichi NAKASHIBA et al. :

Serial No. NEW :

Filed June 8, 2000 :

APPARATUS FOR AND METHOD FOR POLISHING WORKPIECE

CONSENT OF ASSIGNEE TO REISSUE AND 37 CFR 3.73(B) STATEMENT

Assistant Commissioner for Patents,
Washington, D.C.

Sir:

The undersigned, assignee of the entire interest in the above-mentioned letters patent as evidenced by an Assignment of record in the Patent Office at 8581, frames 0552-0555 on June 25, 1997, hereby assents to the above-identified reissue application.

In accordance with 37 C.F.R. 3.73 the assignee hereby certifies that the evidentiary documents with the respect to its ownership have been reviewed and that, to the best of the assignees knowledge and belief, title is in the assignees seeking to take this action.

The undersigned (whose title is supplied below) is empowered to sign the certificate on behalf of the assignee.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further, that these statements

are made with the knowledge that wilful false statements, and the like so made, are punishable by fine or imprisonment, or both, under §1001, Title 18 of the U.S. Code, and that such wilful false statements may jeopardize the validity of the application or any patent issuing thereon.

July 25, 2000
Date

(Signature of assignee)

President
Title